Leonardo da Vinci

Leonardo da Vinci is one of the greatest artists who has ever lived. He is also among the greatest scientists. He experimented with unusual ways to mix paint and use colours. He created new painting techniques and original ways to compose pictures. He studied everything he saw—from living things to machines, using his incredible drawing skills to record them in detail. Then he used his observations to think up plans for inventions that were not built until hundreds of years later, such as a telescope, a tank and a helicopter!

LEONARDO’S CHILDHOOD

Leonardo was born on April 15, 1452, in the small town of Vinci, near Florence, in Italy. (His name means in Italian, “Leonardo of Vinci”.) His father was a wealthy Florentine official who did not marry his mother, a simple peasant woman.

Leonardo was brought up by his mother’s family in the beautiful Tuscan countryside. As a small boy, he spent hours exploring the woods, fields and streams. He loved to watch insects, animals and birds, and to examine different plants and flowers, then make sketches of them. His restless curiosity, interest in nature and keen eye for observation shaped the whole course of his life.

LEONARDO BECOMES A CRAFTSMAN

At the age of about 12, Leonardo went to live with his father in Florence. The great city was then a bustling centre for training master artists and for brilliant students of literature and science. Leonardo was sent to school to learn reading, writing and maths, and he became a fine musician. However, he showed such a talent for drawing that he was taken on as an apprentice by one of the leading artists in the city, Andrea del Verrocchio.

In Verrocchio’s workshop, Leonardo began to learn how to mix different types of paint, make brushes and prepare canvases for painting. He studied the art of fresco (painting using watercolours on wet plaster)and learnt how to sculpt. Artists in those days knew many other skills. Wealthy people paid Verrocchio to create bronze church bells, musical instruments and furniture, to make compasses for ships and to cast objects in gold and silver.

Leonardo studied all the crafts in the workshop, and became fascinated by the variety of tools and machines used there. He examined how each of the pieces of technical equipment worked and made careful drawings of them. Leonardo carried a sketchpad with him at all times, so he could make accurate drawings of anything around Florence that interested him. He began to think about how everyday machines worked, such as the waterwheels that turned millstones to grind corn. And he studied the specialist machines being used on an enormous construction site where the city cathedral was being built.

AN ARTIST IN FLORENCE

By 1472, Leonardo had finished his apprenticeship with Verrocchio. However, he stayed working in the great craftsman’s workshop as his assistant. Verrocchio thought the 21-year-old was so skilled that he allowed Leonardo to help with a masterpiece he was working on called *The Baptism of Christ*. Leonardo painted an angel kneeling in the left of the picture, and some of the background. He used delicate colours to show feelings on the angel’s face, and tried a new idea for painting haziness in the landscape to try to show distance. In those days, artists could only paint flat pictures; they did not know how to show perspective.

By 1478, Leonardo had set up a workshop of his own. Two of his first paintings were gentle, touching portraits of Mary with baby Jesus, called Madonnas. Between 1480 and 1481 he also created a lovely, small painting called the *Annunciation*, showing the Bible story of how Mary was once visited by an angel. Leonardo brilliantly captured the meeting of the human and the spiritual worlds by setting the figures in a deep, misty, magical landscape, with exquisitely detailed, lifelike wildflowers and plants around the angel’s feet.

Many wealthy people in Florence began to ask Leonardo to create works of art for them—in particular the ruler of the city himself, the great Lorenzo de’ Medici. Strangely, Leonardo never carried out work on one big order, which was for a painting in the chapel of a palace, the Palazzo Vecchio. He also left several other works unfinished. One of these was a portrait of St Jerome. Another was an order from a monastery for his first large-scale painting, *The Adoration of the Magi*, showing the visit of the Three Wise Men to baby Jesus. Perhaps Leonardo did not finish the paintings because he was engrossed with other work he was doing in private. Leonardo was not only still studying and sketching machines, such as pumps and army equipment. He was also planning new machines of his own.

WORK AT THE COURT OF MILAN

In 1482, Lorenzo de’ Medici sent Leonardo on an important mission. He asked him to take a silver musical instrument called a lute as a peace offering to the warlike ruler of Milan, Duke Lodovico Sforza. Leonardo wrote a daring personal letter to deliver to the duke at the same time. In it, he described the amazing ideas he had for incredible new machines, which would be perfect for the Duke’s army. These included armoured vehicles, moveable bridges and original designs for catapults, cannons and other weapons. At the end of the letter, Leonardo added that he also happened to be a skilled painter, sculptor and musician. He offered to create a bronze horse statue to honour the Duke’s father.

The Duke was highly impressed and invited Leonardo to work for him as an engineerand painter. Leonardo set up a studio with pupils and assistants helping him on many different projects. From 1483 to 1485 he worked on two versions of a wonderful picture called *The Virgin of the Rocks*. Then he was asked to paint a massive fresco on the wall of a dining room in a monastery. For the next two years, Leonardo created a masterpiece called *The Last Supper*, which showed the final meal Jesus Christ shared with his close followers.

However, much of Leonardo’s time was taken up with scientific studies. He was employed on the duke’s many war campaigns, advising on new ideas for weapons and building defences. He also produced models for the building of a magnificent dome for Milan cathedral, drew up plans for other great buildings, and designed theatre sets and costumes. He studied how humans and animals moved, explored possibilities for inventing flying machines, and thought deeply about the moon, stars and planets. He also became firm friends with a mathematician called Luca Pacioli, who was working on the relationship between distances. Leonardo made a series of drawings to illustrate Pacioli’s ideas, and studied how he could use mathematical rules to create paintings that looked solid, deep and lifelike.

FOUR YEARS IN FLORENCE

Leonardo stayed in Milan for 18 years. Then at the end of 1499, French soldiers attacked the city and conquered it. The 48-year-old artist returned to Florence once more. Not long afterwards Florence was caught up in its own war against the city of Pisa. In 1502, Duke Cesare Borgia asked Leonardo to become his chief architect and engineer. He worked hard, designing and building forts. He also drew up plans to cut off Pisa’s water supply and force the city to surrender. His brilliant ideas involved changing the direction of a river and also building canals, but these were not carried out.

Leonardo saw horrors during the war, which inspired him to plan an enormous painting called the *Battle of Anghiari* for the great hall of the Palazzo Vecchio. However, he only got as far as making detailed sketches and a full-size drawing. Instead, Leonardo turned to studying the flight of birds and experimenting further with his designs for flying machines. He also painted several famous portraits. The only one that still survives is a captivating picture of a woman with a mysterious smile, called the *Mona Lisa*. It is probably the most famous painting in all the world today.

LEONARDO’S LATER YEARS

In 1506, Leonardo returned to Milan, at the request of the French governor there. The King of France himself, Louis XII, was living in Milan at the time, and just a year later he appointed Leonardo to be his court painter. However, Leonardo continued to devote lots of time to engineering projects and scientific investigations, such as examining fossils to work out what they were.

After the governor of Milan died, Leonardo went to Rome in 1514 to work for the brother of the pope. Although he completed one magnificent painting, a portrait of St John the Baptist, he spent most of his time studying and experimenting. By examining animal parts from a butcher’s shop, he produced brilliant models of how the heart works. He tried making giant, rounded mirrors because he wanted to see the moon and stars close-up. And by studying he plants he discovered that the same patterns exist in many natural things.

Shortly after the pope’s brother died, in 1516, Leonardo went to live and work in France. He was 64 years old. King Francis I gave Leonardo the title of “First painter, architect and mechanic of the king”, and set him up in a house near his own palace in Amboise. He paid Leonardo well and left him to do as he pleased, visiting him now and again to enjoy fascinating conversations. Leonardo began the huge job of sorting out all the scientific papers he had produced during his lifetime. He died before he was able to finish, on May 2, 1519.

| Did you know? |
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| • Leonardo never finished the horse statue he offered to make for the Duke of Milan. He got as far as creating an enormous clay model, but when the French armies invaded the city, they destroyed it by using it for archery practice! |
| • When Leonardo wrote in his notebooks, he wrote backwards (from right to left) using "mirror writing". No one is sure why. Some people think that he wanted to make it hard for others to read his studies and steal his ideas. Other people think that it was just easier for him, because he was left-handed. Whatever the reason, when Leonardo wrote documents for other people to read, he wrote in the usual way. |
| • In Leonardo's day, very few people grew up left-handed like him. Everyone was very supersitious and many believed that the left side of the body was evil and unlucky. Children who showed signs of being left-handed were usually forced to using their right hand instead. Leonardo was also a vegetarian, which was equally unusual in those times. |
| • Leonardo was buried in the palace church at Amboise in France. However, the building was destroyed three hundred years later, during the French Revolution, so his grave can no longer be found. |
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Thomas Alva Edison

One of the most remarkable and creative people ever to have lived was an American inventor and scientist called Thomas Edison. In the late 19th and early 20th centuries he created hundreds of inventions that greatly changed everyday life—and his influence is still felt today. Without Thomas Edison we may never have had lights in our home, or the opportunity to buy music from shops or to visit a cinema to see the latest blockbuster. It is hard to imagine life without these things.

EARLY LIFE

Thomas Alva Edison was born in Milan, Ohio, on February 11, 1847. He attended school for only three months. As an 11-year-old boy he worked in the family market garden, delivering produce on a pony and trap. His main interest at this time was science, and he had a great thirst for technical knowledge. In his spare time he experimented with printing presses and with electrical and mechanical equipment. When he was 12, in order to buy books and chemical apparatus to continue his studies, he began selling newspapers and country produce on the Grand Trunk Railway. He even had a laboratory in a compartment on the train. In 1862 he began publishing the *Grand Trunk Herald*, a weekly newspaper that he produced on board the train.

FIRST INVENTIONS

At 16 he saved the life of a railway station official's child and was rewarded by being taught telegraphy, which he soon mastered. He moved about from one station to another, working as a telegraph operator for the Grand Trunk Railway, and within a year he was working for the Western Union Telegraph Company. The railway brought him into contact with engines and electricity, and he soon made his first important invention: a telegraphic repeating instrument that enabled messages to be transmitted automatically over a second line without the presence of an operator.

Edison moved to Boston, Massachusetts, and devoted all his spare time to research. In 1868 he gained his first official patent for an invention. It was for an electric vote recorder, for use in the American government’s House of Representatives. It was never used, probably because it was not practical enough. He then invented the Edison Universal Printer. It was the world's first really practical tape printing machine, and was used in stock exchanges and news agencies all over the world.

In 1874 he devised a system of quadruplex telegraphy. This was an automatic telegraph system that made itpossible to transmit several messages on one line simultaneously. For this and the sale of other telegraphic appliances, the Western Union Telegraph Company paid Edison US$40,000. It was a huge sum of money and in 1876 Edison built his own laboratory. He could now afford to invent full time, and he began taking out patents year after year.

MUSIC, LIGHTS AND FILM

Edison's next important invention was the carbon telephone transmitter. This played a vital role in the development of the telephone, which had recently been patented by the American inventor Alexander Graham Bell.

In 1877 Edison invented the phonograph, which was the world's first machine for both recording and playing back sound—it was the equivalent of the CD of today. His phonograph had a tinfoil-covered rotating cylinder onto which mechanically recorded sounds were made by converting vibrations of air into a groove that was engraved on it. He later improved on this with the gramophone, where the sound was impressed onto a disc instead of a cylinder. The gramophone had a diamond needle and other improved features.

Two years later he showed the world his incandescent electric light bulb, which was probably his most important creation. It had taken more research and experimentation to perfect than any of his previous inventions. It was a great success. Now Edison had to create an electrical generating system. He knew that huge electric dynamos would be needed to generate the necessary electric current to power the millions of light bulbs that would illuminate America's towns and cities. In 1882 he developed and installed the world's first large central electric-power station, located in New York. In the future his direct electric current system was bettered by an alternating-current system developed by fellow American inventors Nikola Tesla and George Westinghouse. Soon the major cities of the world were adopting Edison's ideas to power and light their homes, streets, shops and factories.

In 1888 Edison invented the kinetoscope, an early film projector. It was the first machine to produce "cinema" films, and did so by showing a rapid succession of individual images. By synchronizing his gramophone and kinetoscope, he produced, in 1913, the first sound film. His other later discoveries include the mimeograph (a duplicating machine), the microtasimeter (a machine to detect tiny changes in temperature), a wireless telegraphic method for communicating with moving trains, and the nickel-iron storage battery, which was the result of many thousands of experiments and is very important in heavy industry. His later work consisted mainly of improving and perfecting previous inventions.

A REMARKABLE LIFE

Edison’s great achievements were recognized throughout the world and he was awarded many medals and prizes. In 1878 he was appointed Chevalier of the Légion d'honneur of France and in 1889 was made Commander of the Légion d'honneur. In 1892 he was awarded the Albert Medal of the Royal Society of Arts of Great Britain. During World War I he worked for the United States government, and in 1928 he received the Congressional Gold Medal “for development and application of inventions that have revolutionized civilization in the last century”.

Thomas Edison died in West Orange on October 18, 1931. Many people have made great contributions to life, but few have made as great a contribution as Thomas Edison in shaping modern society.

| Did you know? |
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| • In 1882, Edison took out an astonishing 107 patents on new inventions. That is more than one every three days. |
| • In one of the most famous quotes in history, Edison once said: 'Genius is 1 per cent inspiration and 99 per cent perspiration.' He truly believed in the importance of hard work above all else. |
| • Sound was first recorded by Thomas Edison in 1877. The first reproduced phrase, 'hello', was actually recorded on a telephone repeater, but Edison invented the more sophisticated phonograph the same year. |
| • Thomas Edison is known as the inventor of the light bulb, but it is not widely known that he used to sit in a dark cupboard to think up all his best ideas and inventions. |
| • Edison's home and laboratory in West Orange, New Jersey, where he lived from 1887 until his death, were established as the Edison National Historic Site in 1955. |
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Isaac Newton

On Christmas Day, 1642, a boy was born in the manor house of Woolsthorpe, near Grantham, in Lincolnshire. He was born prematurely and was tiny, but he survived to become one of the greatest scientists the world has ever known.

NEWTON’S CHILDHOOD

Isaac Newton was named after his father, a farmer who had died a few months before Isaac was born. When Isaac was two years old, his mother Hannah married again. Isaac was brought up at Woolsthorpe by his grandmother. He did not like his mother’s remarriage and hated his stepfather, the Reverend Barnabus Smith.

His mother had three children by her second husband. When Isaac was 11, his stepfather died, and his mother, stepbrothers and sisters moved to live with him and his grandmother.

Isaac was sent to the Free Grammar School in Grantham. It was 8 kilometres from home, and he stayed with a family in the town. Isaac’s school reports were not very good and his mother thought he might be better off managing the farm. But Isaac did not get on too well with that either. Luckily, an uncle noticed his cleverness and love of learning. He persuaded Isaac’s mother to send him back to school. He also encouraged Isaac to go to university.

NEWTON GOES TO UNIVERSITY

In 1661 Newton entered Trinity College, at the University of Cambridge. He studied law, but he had a lot of freedom in his studies and he became interested in mathematics and astronomy. He read about the work of the astronomers Nicolaus Copernicus and Johannes Kepler, and worked through many mathematics books by himself. His mind was buzzing with ideas.

In 1665 the university was closed because of the Great Plague, which swept through southern England, killing thousands. Newton went home and for a year worked on mathematics and physics and developed his theory of gravity. This was probably the most creative time in his life.

NEWTON BECOMES A SCIENTIST

Back at the University of Cambridge, people began to recognize his ability. In 1669, at the age of just 27, he became a professor of mathematics there. For nearly 20 years, as well as giving lectures, Isaac Newton worked on his ideas in mathematics and physics. Many scientists admired his work. One was Edmond Halley, an important astronomer. Halley encouraged Newton to write up his work and publish it.

Newton needed the encouragement. He was a shy man, but could become angry if his work was criticized. He held long-lasting grudges. He did not publish his work for years because he was afraid it might be attacked.

In 1671 Newton was made a Fellow of the Royal Society—a society in London that only very important scientists are invited to join. He had been experimenting with light and told the Royal Society about his discoveries. Another important scientist belonging to the society, called Robert Hooke, did not agree with his ideas. Nor did the Dutch scientist Christiaan Huygens. Newton and Hooke became enemies, though they were polite in public.

In 1687 his friend Halley published Newton’s most famous work. It was written in Latin. It was called *Philosophiae Naturalis Principia Mathematica*, or *Mathematical Principles of Natural Philosophy* (science was called “natural philosophy” in those days). It is usually known as the *Principia*.

In this work, Newton described his theories about liquids and gases, and presented his theory of gravity. It was widely admired. But Hooke said that Newton had taken some of his ideas. Newton and Hooke continued their quarrel for years. Newton waited until Hooke died in 1703 before publishing his work on light.

Newton’s work on mathematics involved him in another argument. During the year he spent at home because of the plague, he had started to work on the mathematics of things that change. We now call this branch of mathematics calculus. Another famous scientist, Gottfried Leibniz, had come up with the same ideas a little later than Newton. They argued about who invented calculus first. The argument lasted until Leibniz died in 1716, and even after that.

All this anger and resentment led Newton to a nervous breakdown in 1678, and another in 1693. He turned away from people and shut himself away for long periods. Newton was deeply religious. Alongside his work in science, he pored over the Bible. He thought there were deep meanings hidden in its words. He was also fascinated by alchemy—the attempt to change different substances into gold.

MASTER OF THE MINT

Newton joined the Royal Mint in London in 1696. The Royal Mint makes the coins used as money. Three years later he became Master of the Mint and a rich man, but he never married, and he lived simply.

Newton was now 57 years old. For the rest of his life he was in charge of the Royal Mint. He also kept up his argument with Leibniz. In 1703 Newton became president of the Royal Society. Two years later he was knighted Sir Isaac Newton by Queen Anne.

Isaac Newton died in London on March 20, 1727, at the age of 85. He was the first scientist to be buried in Westminster Abbey.

WHAT WERE NEWTON’S ACHIEVEMENTS?

Isaac Newton is most famous for his theory of gravity. The story goes that he was sitting in the garden one day when he saw an apple fall from a tree. He wondered why it did not just float in the air instead of falling.

He realized that the force that made the apple fall to the ground was the same as the force that kept the Moon going round the Earth. He was able to describe the orbits of all the planets using this force—the force of gravity. But there were problems with his theory too. One basic problem was that Newton never really explained gravity. He just said that any two masses pull each other.

The problems were only solved many years later, in the 20th century, when Albert Einstein worked out his Theory of General Relativity. But Newton’s theory was good at describing the way objects fall and how planets orbit the Sun. We still use it for many things.

Newton also showed that white light is a mixture of all the colours of the rainbow. He used a prism to split white light into its separate colours. He made many other studies of light. Newton believed that light is a stream of particles. Other scientists agreed with Christiaan Huygens that light must be a wave. Now we know that Newton was not wrong—light acts as both a particle and a wave.

Newton’s interest in light came from his efforts to make a good telescope. He invented a reflecting telescope, which used mirrors instead of lenses, in 1668. We call them Newtonian telescopes.

He also invented the mathematical method of calculus. Though Leibniz invented the same method, Newton had thought of it earlier. We now use calculus as a basic tool in many problems in science and mathematics.

Newton’s *Principia* is often described as the greatest scientific work ever written. It seems hard to believe that one person could achieve so much. Newton could be difficult, and sometimes unpleasant, but he devoted his life to searching for truth and he knew that there was a great deal more to learn. He wrote:   
  
“To myself, I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.”

| Did you know? |
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| • In addition to being a great scientist, Isaac Newton was also a Member of Parliament. He tried to prevent King James II from turning the universities into Catholic institutions and was elected Member of Parliament for the University of Cambridge in 1689 to make sure that this did not happen. |
| • Isaac Newton was a deeply religious man and he devoted a great deal of his time to investigating religion. In fact he owned more books on that subject than he did on science. He also sought to find evidence in the Bible for much of the mythology of Ancient Greece. |
| • Some people today have accused Isaac Newton of trying to destroy the reputation of the scientist Robert Hooke, with whom he had lots of arguments. Although no real evidence supports this, many believe that some of Newton's great scientific ideas were actually those of Hooke. |
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Marie Curie

Marie Curie was probably the greatest woman scientist in history. In the late 19th and early 20th centuries her discoveries in a new area of science known as radioactivity made her famous throughout the world. She would pay a high price for her success.

MARIE’S EARLY LIFE

Marie Curie was born Maria Sklodowska on November 7, 1867, in Warsaw, Poland, which was then part of the Russian Empire. Her father was a mathematics and physics teacher. Marie was interested in science as a child, winning a gold medal at school for her studies. She found the lack of opportunities for a Polish woman in a Russian-dominated land very frustrating. After working as a governess in Warsaw, she moved to Paris when she was 24 to continue her studies. She studied physics and mathematics at the famous Sorbonne university. In 1894 she met Pierre Curie, who was also a physicist, and in the following year they married. Together they began a great partnership of scientific discovery.

DISCOVERING RADIUM

In 1895 the scientific world was in a state of intense excitement. German scientist Wilhelm Roentgen had just discovered a new form of radiation, which he called X-rays. The very next year, French scientist Antoine Henri Becquerel discovered that the chemical element uranium emitted another new radiation.

Marie was interested in whether other elements emitted this new radiation. She began working on a naturally occurring black substance called pitchblende, from which uranium is produced. In 1898 she discovered that pitchblende produced very strong emissions of radiation, and she called these emissions “radioactive”. Marie realized that this radioactivity was so strong that it had to be due to the presence of one or more elements in the pitchblende and not just the uranium. After a huge effort, she and Pierre collected tiny amounts of two new elements that were causing the radioactivity: she named them polonium and radium.

Many scientists were not so sure about these discoveries and wanted to see more. In a shed in the grounds of the physics school where they worked, Marie and Pierre spent four years collecting 0.1 gram of pure radium and so proved to the world that they were right.

GREAT SCIENTIST

The world soon recognized their achievement, and Marie and Pierre, together with Becquerel, were awarded the Nobel Prize for Physics in 1903 for their work on radioactivity. After Pierre was killed in a road accident in 1906, Marie devoted herself to her work on radioactivity as well as teaching at the newly created Pierre Curie Institute. She was awarded the Nobel Prize for Chemistry in 1911 for discovering radium. Marie Curie is the first and only person to be awarded two Nobel Prizes for science.

During World War I, Curie devoted herself to using the controlled radioactivity of radium for medical purposes, helping develop the technique of radiotherapy to treat some cancers. Her legacy can be seen in hospitals throughout the world where this is now used. She strongly believed in the importance of science helping humanity.

Because no one knew about the dangers of radioactivity, Curie had been exposed during her career to massive doses of radiation. We now know that overexposure can destroy cells in the human body. She died on July 4, 1934, from leukaemia, almost certainly caused by the radioactivity of the radium she had discovered.

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Albert Einstein

Imagine completely changing the way in which people see the world. What an amazing achievement that would be. How famous you would become! That is what happened to Albert Einstein.

ALBERT EINSTEIN’S CHILDHOOD

Albert Einstein was born in Ulm, in southern Germany, on March 14, 1879. He was the eldest child of Hermann and Pauline Einstein.

When Albert was still a baby, the family moved to nearby Munich. Hermann set up an engineering business there with his brother, Jakob. Albert was an unusual child who did not start to talk until he was three years old. But he seemed fascinated by the natural world, and he loved music. He began learning to play the violin at the age of five and became a fine musician.

At school, Albert did not like the strict timetables and he found the lessons boring. His teachers thought him lazy and a dreamer.

Things did not go well for the Einstein family. Their business was failing and Albert’s parents decided to leave Germany and move to Milan in Italy. Albert left school in Munich to join them there. He was now a young man.

EINSTEIN IN SWITZERLAND

After a year in Milan, Einstein went to Switzerland to study. There he trained to teach physics and mathematics at the Swiss National Polytechnic in Zurich. Einstein did not enjoy formal studies. He missed classes, preferring to study physics on his own. He only managed to pass his exams by borrowing the notes of a classmate.

The professors at the polytechnic were not impressed. Einstein could not become a university teacher, so he worked as a tutor until 1902 when he got a job as a technical assistant in the Swiss Patent Office in Bern.

During the day, Einstein worked at the Patent Office, but in his spare time he was developing his ideas in physics. In 1905 Einstein received a doctorate from the University of Zurich. He also published three very important scientific papers.

One paper was about the movement of atoms. The second was about the nature of light. For many years, scientists thought that light was a wave. Einstein showed that it sometimes acted as a particle. Isaac Newton had suggested that light was a stream of particles in the 17th century. Now, Einstein showed that he was right, at least in some situations.

The third paper challenged the way that Newton had looked at the world. It introduced the first of Einstein’s famous theories of relativity. In his Special Theory of Relativity, Einstein started to think about space and time in a new way. He looked at things moving in relation to each other, such as a train overtaking a car. From these studies he found that there was something special about the speed of light. The speed of light (measured in a vacuum, or empty space) is always the same. And nothing can travel faster than the speed of light.

Strange things happen to objects moving close to the speed of light. If we watched a spaceship going faster and faster, until it was travelling close to the speed of light, we would see the clocks on the spaceship going slower. As the spaceship reached the speed of light, the clocks would look to us as though they had stopped!

Another idea that Einstein introduced was that energy and matter can be changed from one to the other. He wrote an equation to show how the two are connected: *E* = *mc*2. It is probably the most famous equation in the world.

These ideas were startling at the time. Very few people understood Einstein’s work. But some scientists did, and they realized its importance. The universities started to take a serious interest in this Patent Office clerk.

GERMANY AND FAME

For a few more years, Einstein continued to work at the Patent Office. He then moved into a university teaching post. He taught at Prague and Zurich, and ended up teaching in his old polytechnic. In 1913 he returned to Germany. He was made director of the Kaiser Wilhelm Institute for Physics in Berlin. He was also a professor at the University of Berlin. Einstein had left the Patent Office far behind.

He continued to work on his new view of space and time. Then in 1916 he published the General Theory of Relativity. It caused a sensation.

For over 200 years, Newton’s theory of gravity had been used to describe how things fall to Earth and how planets orbit the Sun. But it did not always give the orbits exactly. There was a particular problem with Mercury’s orbit, which did not quite fit. And there was another problem: Newton did not really explain gravity. He just said that things attract each other.

Einstein’s General Relativity showed that space and time are very closely linked. We should really think of them together, as space-time. Einstein showed how any object with mass changes the space-time around it, rather like a ball creates a curve in a rubber sheet it is sitting on. This curving of space and time is felt as gravity.

The idea seemed incredible, but it solved all the problems with the planetary orbits. And like all good theories in science, General Relativity made predictions that could be tested. If Einstein’s ideas were right, then the light of a star appearing behind the Sun would be bent by the Sun’s mass. This could only be tested during a solar eclipse, when the Sun’s dazzling disc was hidden. There was an eclipse in 1919. Across the world, people waited eagerly as Einstein’s theory was put to the test. His prediction proved to be right.

Einstein became very famous. He was surrounded by photographers and newspaper reporters, and showered with honours. In 1921 he was awarded the Nobel Prize for Physics.

WAR AND AMERICA

Einstein had strong beliefs about politics. He spoke out against Germany’s role in World War I. At that time he was a pacifist—someone who is against all war.

Later, his beliefs changed. Einstein was Jewish. He was involved in the movement (called Zionism) to create a state of Israel where Jews from all over the world could settle. Even though he was now a celebrated scientist, he was hated by those who hated all Jewish people. When Adolf Hitler and the Nazis came to power in Germany in 1933, Einstein left for the United States.

Though he had been a pacifist in World War I, Einstein believed that Hitler had to be stopped. Like others, he was worried that Hitler might be developing a powerful new kind of bomb—the atomic bomb. But in the end it was the United States that used two atomic bombs against Japan in 1945. After World War II, Einstein took part in campaigns demanding that all atomic bombs, now known as nuclear weapons, should be removed.

In the United States, Einstein joined the Institute for Advanced Study in Princeton, New Jersey. He was by now the most famous scientist in the world. He still kept working to try to find an even grander theory than his relativity—one that would bring together all the forces we know about.

There were other developments in physics. New ideas were spreading about the way tiny particles far smaller than atoms behave. The world of the very small—the quantum world—was turning out to be amazing too. But Einstein could not accept these new thoughts, although he had suggested startling ideas himself. He tried to develop his theory without them. And in this he failed.

Albert Einstein died at Princeton on April 18, 1955. His work had changed the way we understand the universe.

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Benjamin Franklin

Benjamin Franklin was an American scientist, inventor, diplomat, statesman, printer and writer. He was the most famous American of his time and was a founding father of the United States of America.

BENJAMIN’S EARLY LIFE

Benjamin Franklin was born in Boston, Massachusetts, on January 17, 1706. He went to school for only a few years. At the age of 10 he began training in his father’s candle-making shop. When he was 13, his father sent him to work with his older brother James.

James Franklin taught his brother about the printing business. Benjamin learned to work a printing press and sold newspapers, and also began writing articles. Benjamin also taught himself maths, science, literature and foreign languages.

In 1724 the 18-year-old Benjamin Franklin sailed to London. There he learned all he could about printing and publishing. When he returned to America after two years he settled in Philadelphia, Pennsylvania. There he bought a small newspaper, the *Pennsylvania Gazette.*

A MAN OF IDEAS

Franklin had many ideas on how to improve people’s lives. He organized the first public library in America. He also started the first fire department and one of the first hospitals in Philadelphia. He also helped found a school that later became the University of Pennsylvania. In 1732 he began publishing a popular, witty advice book called *Poor Richard’s Almanack*.

In 1744, Franklin invented the Franklin stove, which provided more heat while using less fuel. He also began experimenting with electricity. In 1752 he invented a lightning conductor, a device that is attached to the highest part of a building and attracts the lightning charge to it. It protects the building by conducting the lightning to the ground, rather than it hitting the building. His scientific ideas and inventions became well known in Europe as well as in America.

POLITICIAN AND DIPLOMAT

From 1757 to 1772 Franklin spent most of his time living in London. He represented the American colonies in British politics. Franklin explained America’s views of British tax policies, such as the Stamp Act, which had been imposed on the colonies in order to pay for their defence. Colonial protest eventually meant the law had to be repealed.

Franklin returned to Pennsylvania in May 1775, one month after the start of the American War of Independence. He served as a representative at the Second Continental Congress, an early American governing body, and was part of the committee that wrote the US Declaration of Independence.

FRANKLIN AND THE AMERICAN WAR OF INDEPENDENCE

Franklin returned to Europe as a diplomat representing the American congress. He helped convince France to lend money to the revolutionaries to fund the war effort. Eventually, France joined America in fighting—and defeating—the British.

Franklin was by now an old man but he helped negotiate the peace treaty with Britain. The treaty was signed in 1783 and recognized American independence, free from control by Britain. Later, Pennsylvania sent Franklin as a delegate to the 1787 convention that planned and wrote the United States Constitution. He was the convention’s oldest delegate. He died in 1790, leaving his *Autobiography* unfinished.

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Galileo Galilei

Galileo Galilei was one of the first modern scientists, and made exciting discoveries about stars and planets using his telescope. He also found out about how things move as they fall to Earth. He was important because of the way he did his work. He observed carefully how things behaved and took notes. He then set up experiments to test his theories.

Galileo knew how to focus on what really mattered in a problem. And he did not just use words to describe how things move. He used mathematics. That meant he could say things very precisely.

Galileo was an important figure in the Scientific Revolution. This brought a new way of thinking to Europe in the 16th and 17th centuries.

GALILEO’S EARLY LIFE

Galileo was born near Pisa, in Italy, in 1564. He lived in Italy all his life. His father was a music teacher. When he was a child, Galileo studied in a monastery. He liked the quiet way of life there and wanted to become a monk. But his father sent him to the University of Pisa to study medicine. Galileo did not find medicine interesting and preferred mathematics. He eventually gave up his medical studies and taught mathematics instead. Soon, important mathematicians started to take notice of him. He became a professor of mathematics and taught at the universities of Pisa and Padua. His work made him famous. The powerful Grand Duke of Tuscany, Cosimo de’ Medici, made him his court mathematician.

GALILEO’S FIRST EXPERIMENTS

In Galileo’s time, people’s ideas about the world came mainly from the famous Greek philosopher Aristotle. Aristotle had said that heavy objects fall more quickly than light ones. Galileo found that Aristotle was wrong. He showed that if you drop a light object and a heavy object from the same height, they will speed up at the same rate and reach the ground at the same time. This was a surprise. It went against Aristotle’s ideas and common sense. But Galileo’s experiments showed that it was true.

Galileo also looked at pendulums. He found that they take the same time to complete a swing, however far they swing.

WHAT DID GALILEO DISCOVER?

In 1609, Galileo heard of an amazing Dutch spyglass that could make faraway things seem close at hand. He was fascinated. Soon he was making his own telescopes. They were much better than the early Dutch ones. Then one day he turned his telescope to the night sky. What he saw astonished him. Galileo found that the Moon had mountains, valleys and craters. He discovered that Jupiter had four little stars of its own going round it (he was seeing Jupiter’s four biggest moons). He found that the pale glow of the Milky Way was in fact the light of many thousands of faint stars. He watched sunspots. And he saw that the planet Venus showed phases, appearing as waxing and waning crescents just like the Moon.

These discoveries did not fit in with people’s ideas about the universe. Aristotle had taught that the heavenly bodies were smooth and perfect spheres. Yet the Moon clearly was not like that.

Aristotle and the Greek astronomer Ptolemy had believed the Sun and planets went round the Earth. In 1543 a book by Nicolaus Copernicus, a Polish astronomer, suggested that the Earth and planets went round the Sun instead. By Galileo’s time, many people thought it was true that the planets went round the Sun, but they still believed the Sun went round the Earth. Galileo could see that his work supported Copernicus. But Copernican theory went against the teaching of the Catholic Church. The Bible said that the Earth did not move, and was at the centre of the universe.

GALILEO AND THE CHURCH

In Galileo’s day, people could be tried and even killed as heretics if they wrote books that went against the Church’s teaching. The Inquisition was responsible for trying heretics. Galileo hoped he would be safe because the Pope liked his work. So he wrote a book showing that he believed that Copernican theory was probably true. But the book was banned and Galileo was tried by the Inquisition. He was forced to say he had been wrong, and was sentenced to life imprisonment, although he was allowed to live at home. He carried on working on moving objects, and wrote his most important book in these last years. Galileo died in Arcetri, near Florence, in 1642.

Galileo’s trial became famous. He had not wanted to go against the Church. He was a religious man. But he felt that people should accept what science had shown to be true when they interpreted the Bible. He thought you should not believe it blindly word for word.

Galileo only had simple telescopes. And not all of his arguments were correct. But now we have plenty of evidence that the Earth is just another planet going round the Sun. We have even found planets orbiting other stars.

| Did you know? |
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| • When Galileo left the University of Pisa in 1585 he did so without having passed his degree, although it had been medicine that he was studying and not the astronomy or physics that he would later be acclaimed for. |
| • In 1992 the Roman Catholic Church officially apologized for condemning Galileo to life imprisonment for going against their teachings in claiming that the Earth revolved around the Sun and not the other way round. After almost five centuries the Church had finally admitted that it was wrong and that Galileo was right. |
| • Legend has it that Galileo dropped two objects from the Leaning Tower of Pisa to show that if you drop a light object and a heavy object from the same height, they will speed up at the same rate and reach the ground at the same time. This story was first told by his last pupil and first biographer, Vincenzo Viviani, although many believe that at best it is more probably an exaggerated version of an actual event. |
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